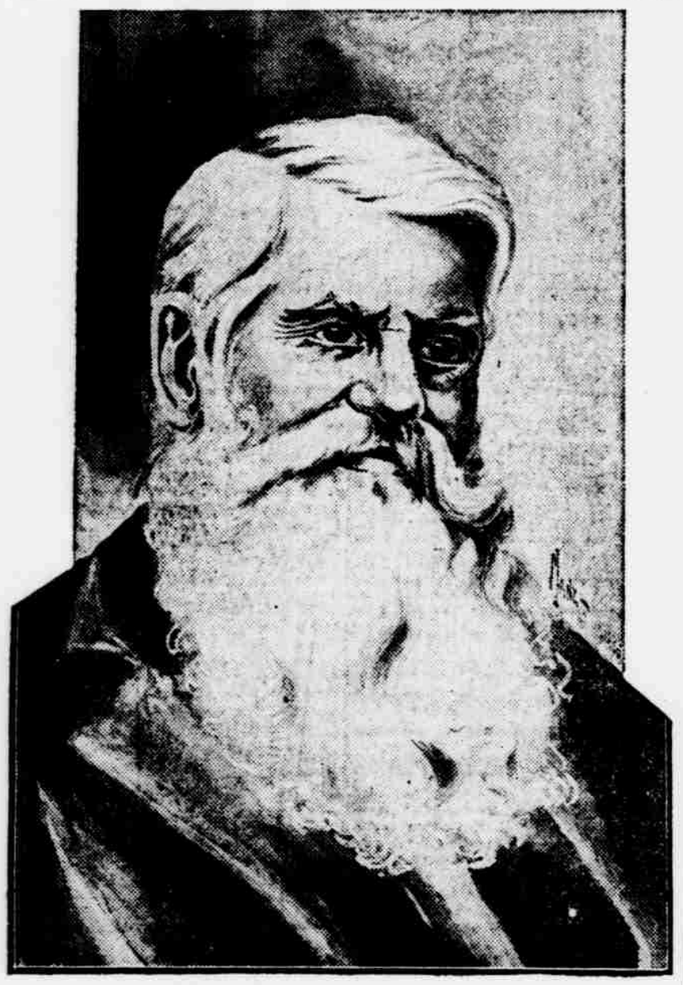
"The Progress of the Century," by Famous Specialists.

EVOLUTION. By Alfred Russell Wallace.

THIS article on Evolution, by Alfred Russell Wallace, is the first of a series of papers by eminent men on the record of human progress in the Nineteenth Century. The world's literature, astronomy, surgery, medicine, religion and other subjects that are involved in the great world-movement of this wonderful century will be discussed by their most notable living exponents. The series will run for about fourteen weeks, and, complete, will be a valuable review of the Nineteenth Century's progress.



ALFRED RUSSELL WALLACE.

Alfred Russell Wallace and Darwin worked along the same lines, and came to the same conclusions at the same time.

One of the most striking of coincidences in the literary and scientific world occurred on a certain day in 1858. Papers were to be read before the Linnean Society of England, and Mr. Wallace, being in Asia, mailed his contribution to Mr. Charles Lyell so that it might be read at the meeting. It was entitled "The Tendency of Varieties to Depart From Their Original Type." At the same meeting Darwin's article on "The Tendency of Species to Form Varieties" was read.

This was a strange coincidence. Two thinkers, patiently laboring in far distant fields, arrive at the same conclusions, forward their views, which are read on the same day at the annual meeting of a scientific society of which they are members.

Alfred Russell Wallace was born in Monmouthshire, England, in 1822, and comes of Scotch ancestry. He was educated to be a land surveyor and architect, the plan being that he form a partnership with an elder brother who had chosen that profession. However, the mysteries of Nature called him, and he answered.

He discarded his special studies in 1845, and devoted himself to natural history. He was with the Bates expedition up the Amazon River, South America, from 1848 to 1852. Studying the mysteries of life in this almost unknown region, he endured the heat of a torrid sun, the dangers of fever. Serpents and venomous insects surrounded him. The flora was charged with poison. For four years the disciple of science lived among the Indian tribes, collecting specimens of vegetable and animal life which promised to throw light on the great problem which he was trying to unravel. The greater part of this collection was lost at sea. Returning to England in 1852 he published his "Travels on the Amazon and Negro Rivers." Later "Palm Trees of the Amazon and Their Uses" appeared.

Still unsatisfied, he went to the Malay Archipelago, where he remained eight years. All this time Darwin was pursuing the same studies in other lands.

It was while he was among the Malays that he wrote the paper on "The Tendency of Varieties to Depart From Their Original Type," and which came to the same conclusions arrived at by Darwin.

Returning from the Malay Archipelago in 1862, he brought with him more than 8,000 birds, and over 100,000 etymological specimens, the classifying and arranging of which occupied much of his attention for several years. In 1869 he published in two volumes his remarkable scientific work, "The Malay Archipelago." Following were his "Contributions to the Theory of Natural Selection," "Geographical Distribution of Animals," "Tropical Nature," "Island Life," "Land Nationalization" and a large work on "Darwinism," published in 1889. "The Wonderful Century: Its Successes and Its Failures," appeared in 1898.

Mr. Wallace is interested in economic problems, as well as in those which have to do with natural history. He is president of the Land Nationalization Society of England now. He has been an investigator of Spiritualism for years, and in 1875 his "Miracles and Modern Spiritualism" appeared. He has written many magazine articles on scientific and popular subjects.

Mr. Wallace is now an old man, but he betrays no signs of age, and no symptoms of physical or mental feebleness show themselves. Not long ago he talked about the Darwinian theory, saying:

"Darwin's fundamental principles have never been shaken. For myself, I have complete confidence in them, and in the permanent influence of his work. * * * I do not believe in the transmission of acquired characters, the evidence seeming to be against it, and this is the chief point on which there is a growth of scientific opinion against Darwin. The discussion is still proceeding, naturalists now being about equally divided. Herbert Spencer takes the same view as Darwin, but Mr. Francis Galton and Weissman between them have almost certainly proved the nonhereditv of acquired variations. But neither of these questions affect Darwin's fundamental principles."

Mr. Wallace believes in recreation. He finds amusement and interest in chess playing and in gardening. He says:

"Darwin was a continuous worker at his own great subject; I am not. I should not be happy without some work, but I vary it with gardening, walking, or novel reading. Even when in the midst of writing a book I do not cease to read light literature."

Wallace admires the earlier books of Thomas Hardy, but does not care for his later works.

"I dislike," he says, "the whole pessimistic school of writers. I have read two of Hall Caine's books, 'The Manxman' and 'A Son of Hagar,' and they are full of misery, horror, pain, trouble. I hate it; that is not human nature. Blackmore is a great genius. Last year I again read 'Lorna Doone' and went to explore the Doone Valley. Of course, we had been told that there was no such place, but we could not believe that; all the surroundings and places are so accurately described. Now," he went on genially, "I don't think a writer ought to mislead one like that!"

Evolution.

WRITTEN FOR THE SUNDAY REPUBLIC.

Among the great and fertile scientific conceptions which have either originated or become firmly established during the Nineteenth Century, the theory of evolution, if not the greatest of them all, will certainly take its place in the front rank. As a partial explanation (for no complete explanation is possible to finite intelligence) of the phenomena of nature it illuminates every department of science, from the study of the most remote cosmic phenomena accessible to us to that of the minutest organisms revealed by the most powerful microscopes; while upon the great problem of the mode of origin of the various forms of life—long considered insoluble—it throws so clear a light that to many biologists it seems to afford as complete a solution, in principle, as we can expect to reach.

The Nature and Limits of Evolution.

So many of the objections which are still made to the theory of evolution, and especially to that branch of it which deals with living organisms, rest upon a misconception of what it professes to explain, and even of what any theory can possibly explain, that a few words on its nature and limits seem to be necessary.

Evolution, as a general principle, implies that all things in the universe as we see them have arisen from other things which preceded them by a process of modification, under the action of those all-pervading but mysterious agencies known to us as "natural forces," or more generally the "laws of nature." More particularly the term evolution implies that the process is an "unrolling" or "unfolding," derived probably from the way in which leaves and flowers are usually rolled up or crumpled up in the bud and grow into their perfect form by unrolling or unfolding. Insects in the pupa and vertebrates in the embryo exhibit a somewhat similar condition of folding, and the word is therefore very applicable to an extensive range of phenomena; but it must not be taken as universally applicable, since in the material world there are other modes of orderly change under natural laws to which the terms development or evolution are equally applicable. The "continuity" of physical phenomena as illustrated by the late Sir William Grove in 1863 has the same general meaning, but evolution implies more than mere continuity or succession—something like growth or definite change from form to form under the action of unchangeable laws.

The point to be especially noted here is, that evolution, even if it is essentially a true and complete theory of the universe, can only explain the existing conditions of nature by showing that it has been derived from some pre-existing condition through the action of known forces and laws. It may also show the high probability of a similar derivation from a still earlier condition; but the farther back we go the more uncertain must be our conclusions, while we can never make any real approach to the absolute beginnings of things. Herbert Spencer, and many other thinkers before him, have shown that if we try to realize the absolute nature of the simplest phenomena, we are inevitably landed either in a contradiction or in some unthinkable proposition. Thus, suppose we ask—is matter infinitely divisible or is it not? If we say it is, we cannot think it out, since all infinity, however it may be stated in words is really unthinkable.

If we say there is a limit—the ultimate atom—then as all size is comparative, we can imagine a being to whom this atom seems as large as an apple, or even a house, does to us; and we then find it quite unthinkable that this mass of matter should be in its nature absolutely indivisible even by an infinite force. It follows that all explanations of phenomena can only be partial explanations. They can inform us of the last change of the last series of changes which brought about the actual conditions now existing, and they can often enable us to predict future changes to a limited extent; but both the infinite past and the remote future are alike beyond our powers.

Rise and Progress of Idea of Evolution.

If we trace, however briefly, the gradual development of knowledge and speculation on this subject, we shall perhaps appreciate more fully the advance we have really made during the present century.

The first speculations on the nature and source of the phenomena of the universe of which we have any knowledge are those of the earlier Greek philosophers, such as Thales, Anaximander, Anaxagoras and Empedocles; and the more important of their teachings are embodied, with some approach to system and with much acuteness of reasoning, in the great poem of the Latin author Lucretius—"On the Nature of Things."

Lucretius was an absolute materialist, for though he did not deny the existence of the gods he refused them any share in the construction of the universe, which, he again and again urges, arose by chance, after infinite time, by the random motions and collisions and entanglements of the infinity of atoms.

It is when he attempts to deal with the origin of living organisms that the absence of all knowledge of chemistry, physiology and histology renders his task impossible and leads him into what seem to us the wildest absurdities. He has an elaborate, but very unconvincing, argument that sensation can arise out of atoms which have no sensation; and, taking the appearance of worms, etc., in the earth and in putrid matter as a proof that they are still actually produced de novo in it, he argues that at some remote epoch the now worn-out earth was more fertile and produced in like manner all kinds of animals. The first human infants he supposes to have been formed at some very remote time in the manner following: "For much heat and moisture would then abound in the fields; and, therefore, when ever a suitable spot offered, wombs would grow, attached to the earth by roots; and when the warmth of the infants, flying the wet and craving the air, had opened these in the fullness of time, nature would turn to that spot the pores of the earth and constrain it to yield from its open veins a liquid most like to milk. To the children the earth would furnish food, the heat raiment, the grass a bed rich in abundance of soft down. * * * Wherefore, again and again, I say, the earth with a good title has gotten and keeps the name of mother, since she of herself gave birth to mankind, and at a time nearly fixed shed forth every beast that ranges wildly over the great mountains, and at the same time the fowls of the air, with all their varied shapes."

The fact that this mode of origin commended itself to one of the brightest intellects of the first century B. C., enlightened by the best thought of the Grecian philosophers, may enable us the better to appreciate the immense advance made by modern evolutionists.

First Real Steps Toward Evolution.

We have now a great blank of fifteen centuries—the dark ages of human progress—after which the era of observation and experiment began and for the first time men really set themselves to study nature, thus laying the foundation for all the great theoretical advances of our time. As leading to the next great step in theories of evolution, we must note the lifelong observations of Tycho Brahe of the apparent motions of the planets; the grand discovery of Kepler that all these apparently erratic motions were due to their revolution round the sun in elliptic orbits, with a fixed relation between their distance from the sun and their periods of revolution; and Newton's epoch-making theory of universal gravitation by which all these facts and many others since discovered are harmonized and explained.

But all this implied no law of development, and it was long thought that the solar system was fixed and unchangeable—that some altogether unknown or miraculous agency must have set it going, and that it had in itself no principle of change or decay, but might continue as it now is to all eternity. It was at the very end of the Eighteenth Century that Laplace announced his "nebular hypothesis," the first attempt ever made to explain the origin of the solar system under the influence of the known laws of motion, gravitation and heat, acting upon altogether different antecedent conditions of things—a true process of evolution.

It is no objection to his grand theories to urge that they do not explain the origin of the matter of the universe, either what it is or how it came to be where we now find it. We can only take one step at a time, and even if in these greater problems any further advance should be as yet denied us, it is still a great thing to have been able to take even one secure step into the vast and mysterious depths of the interstellar spaces.

Evolution of the Earth's Crust.

Although Pythagoras (590 B. C.) believed that sea and land must often have changed places, and a few other observers at different epochs came to the same conclusion, yet, till quite recent times, the earth was generally supposed to have been always very much as it is now; people spoke of "the eternal hills"; and the great mountain ranges, the mighty ravines and precipices, as well as the deep seas and oceans, were believed to be the direct work of the Creator.

It was only in the latter half of the Eighteenth Century that a few observers began to see the importance of studying the nature of the earth's crust, so far as it could be reached in ravines, quarries and mines, and one of the most earnest of these students, Doctor Hutton of Edinburgh, after more than thirty years of travel and study, published his great work, "The Theory of the Earth," which must be considered to be the starting point of modern geology.

But, although Playfair and a few others upheld Hutton's views, they were too novel to receive much support by his contemporaries, and this was especially the case as regards the slow and continuous action of existing causes being sufficient to account for all the known phenomena presented by the crust of the earth. Hence the belief in catastrophes and cataclysms—in great convulsions tearing mountains asunder, and vast floods sweeping over whole continents—continued to prevail, till finally banished by the genius and perseverance of one man—Sir Charles Lyell. His "Principles of Geology" was first published in 1830, and successive editions, revised and often greatly extended, continued to appear till the author's death forty-five years later.

In the earlier years of the Nineteenth Century the standard geological work, both in Great Britain and on the Continent, was Cuvier's "Essay on the Theory of the Earth." In 1857 a fifth edition of the English translation appeared, and there was a German translation so late as 1830—sufficient proofs of its wide popularity. Yet this work abounds in statements which are positively ludicrous to any one conversant with modern geology. It never appeals to known causes, but again and again assumes forces to be at work for which no evidence is adduced and which are totally at variance with what we see in the world to-day.

The method followed by Lyell was the very reverse of that of Cuvier. Instead of assuming hastily that modern causes were totally inadequate, and appealing constantly to purely imaginary and often inconceivable catastrophes, Lyell investigated these causes with painstaking accuracy, applying the tests of survey and time measurement, so as in many cases to prove that, given moderately long periods of time—not a few thousands only, but hundreds of thousands of years—they were fully adequate to explain the phenomena. He also showed that the imaginary causes of Cuvier would not explain the facts, for that everywhere in the crust of the earth we found conclusive proofs of very slow continuous changes, exactly analogous to what now occur, never of great convulsions, except quite locally as we have them now. He showed that modern volcanoes had poured out vast masses of melted rock during a single eruption, covering areas as extensive as those which any ancient volcano could be proved to have ejected in an equally short period; that strata were now in process of formation comparable in extent and thickness with any ancient strata; that organic remains are being preserved in them just as in the older rocks; that the land is almost everywhere rising or sinking as of old; that valleys are being excavated and plateaus or mountains upheaved; that earthquake shocks are producing faults beneath the surface; that vegetation is still preparing future coal beds; that limestone, clays, sandstones, metaphoric and igneous rocks are all still being formed; and that, given time and the intermittent or continuous action of the causes we can now trace in operation, and all the varied features of the earth's surface, as well as all the contortions and fractures which we discover in its crust, and every other phenomenon supposed to necessitate catastrophes and cataclysms, will be again produced.

Lyell's Generalizations Stregthened.

In the massive volumes of the later editions of the "Principles of Geology" all these points are discussed and illustrated with such a wealth of facts and such cogent yet cautious reasoning as have carried conviction to all modern students. It affords us perhaps the very best proof yet given of evolution in one department of the universe—that of the surface and the crust of the earth we inhabit. Not only have all the chief modifications during an almost unimaginable period of time been clearly depicted, but they have in almost every case been shown to be the inevitable results of real and comparatively well-known causes, such as we now see at work around us.

The grand generalizations of Lyell have been strengthened since his death by more complete investigation of certain phenomena and their causes than were possible in his day; while the only objections to them seem to be founded, to some extent, upon a misconception. He has been termed a "Uniformitarian," and it is alleged that it is unphilosophical to take the limited range of causes we now see in action as a measure of those which have acted during all past geological time. But neither Lyell nor his followers make any such assumption. They merely say, we do not find any proof of greater or more violent causes in action in past times, and we do find many indications that the great natural forces then in action—seas and rivers, sun and cloud, rain and hail, frost and snow, as well as the very texture and constituents of the older rocks, and the mode in which the organisms of each age are preserved in them must have been in their general nature and magnitude very much as they are now. Other objections, such as, that the internal forces were greater when the earth was hotter, and that tidal effects must have been more powerful when the moon was nearer the earth, are altogether beside the question until we can obtain more definite measures of past time than we now possess in reference to both geological and cosmical phenomena. It may well be that the physical changes above referred to have been so slow that they would have produced no perceptibly increased effect at the epoch of the early stratified rocks. Lyell's doctrine is simply that of real against imaginary causes, and he only denies catastrophes and more violent agencies in early times, because there is no clear evidence of their actual existence, and also because known causes are quite competent to explain all geological phenomena. It must be remembered, too, that uniformitarians have never limited the natural forces of past geological periods to the precise limits of which we have had experience during the historical period. What they maintain is, that forces of the same nature and of the same order of magnitude are adequate to have brought about the evolution of the crust of the earth as we now find it.

Organic Evolution, Its Laws and Causes.

We now come to that branch of the subject which is the most important and distinctive of our age, and which, in popular estimation, alone constitutes evolution—the mode of origin of the innumerable species of animal and plant life which now exist or have ever existed upon the earth.

The origin of the different forms of life has till quite recent times been looked upon as an almost insoluble problem, although a few advanced thinkers, even in the Eighteenth Century, perceived that it was probably the result of some natural process of modification or evolution, but no force or law had been set forth and established in any way adequate to produce it until the publication of Darwin's "Origin of Species" in 1859. In the later editions of that work Darwin has given a historical sketch of the progress of opinion on the subject. I shall therefore now only notice a few great writers whom he has not referred to.

We have seen what an impossible and even ludicrous explanation had to be given by Lucretius; and from his day down to the middle of the Eighteenth Century no advance had been made. Either the problogical doctrine of a special creation was held to be the only possible one. But in the middle of the Eighteenth Century the great French naturalist, Buffon, published his very important work, "Histoire Naturelle," in fifteen volumes (1749-1767), in which, besides describing the characters and habits of all the animals then known, he introduced much philosophical and speculative thought, which would probably have been carried much further had he not felt obliged to conform to the religious prejudices of the age. We are indebted to Mr. Samuel Butler for having brought together all the important passages of Buffon's voluminous and now little-read works bearing upon the question of evolution, and it is from his volume that I quote.

Buffon's Clear Deductions.

Buffon lays stress on the great resemblance of all mammalia in internal structure, showing that the most unlike creatures may be really alike structurally. He says: "The horse, for example, what can at first sight seem more unlike mankind? Yet when we compare man and horse point by point and detail by detail, our wonder is excited rather by the resemblances than by the differences between them." He then shows that all the parts of the skeleton agree, and that it is only in proportions, the increase of some bones and the suppression of others, that they differ, adding: "If we regard the matter thus, not only the ass and the horse, but even man himself, the apes, etc., might be regarded as forming members of one and the same family." Then, after a few more illustrations, he remarks: "If we once admit that there are families of plants and animals, so that the ass may be of the family of the horse and that the one may only differ from the other by degeneration from a common ancestor, we might be driven to admit that the ape is of the family of man, that he is but a degenerate man, and that he and man have had a common ancestor. * * * If it were once shown that we had right grounds for establishing these families, if the point were once gained that among plants and animals there have been even a single species which had been produced in the course of direct descent from another species, then there is no further limit to be set to the power of nature, and we should not be wrong in supposing that with sufficient time she could have evolved all other organized forms from one primordial type."

This indicates clearly enough his own opinion, but to save himself from the ecclesiastical authorities he at once adds this saving clause: "But no! It is certain, from Revelation, that all animals have alike been favored with the grace of an act of direct creation, and that the first pair of every species issued full formed from the hands of the Creator."

Such examples of disarming religious prejudice are frequent, but he continually recurs to statements as to mutability which neutralize them. Here, for example, is a broad claim for nature as opposed to creation. He has been showing how variable are many animals and how changes of food, climate and general surroundings influence both their forms and their habits, and then he exclaims:

"What cannot nature effect with such means at her disposal? She can do all except either create matter or destroy it. These two extremes of power the Deity has reserved for himself only; creation and destruction are the action of his omnipotence. To alter and undo, to develop and renew—these are powers which he has handed over to the charge of nature."

Here we have a claim for the power of nature in the modification of species which fully comes up to the requirements of the most advanced evolutionist. It is remarkable, too, how clearly he perceived the great factors so important for the evolution of organisms, rapid multiplication, great variability, and the struggle for existence. Thus he remarks: "It may be said that the movement of nature turns upon two immovable pivots—one, the illimitable fecundity which she has given to all species; the other, the innumerable difficulties which reduce the results of that fecundity and leave throughout time nearly the same quantity of individuals in every species." Here the term "difficulties" corresponds to the "positive checks" of Malthus, and to the "struggle for existence" of Darwin; and he again and again refers to variability—as when he says: "Hence—when by some chance, common enough with nature—a variation or special feature makes its appearance, man has tried to perpetuate it by uniting together the individuals in which it has appeared."

Goethe on the Metamorphosis of Plants.

Buffon clearly understood artificial selection, thoroughly appreciated the rapid increase of all organisms, and equally well saw that their inordinate increase was wholly neutralized through such destructive agencies as hunger, disease and enemies, and at the same time he had unbounded faith in the power of nature to modify animal and vegetable forms. We feel assured that this great writer and original thinker only needed freedom to pursue this train of thought a little further and he would certainly have anticipated Darwin's great discovery of natural selection by a whole century. Even as it is, we must class him as one of the great pioneers of organic evolution.

The next distinct step toward a theory of organic evolution was made by the poet Goethe at the very end of the Eighteenth Century in his views of the metamorphosis of plants. He pointed out the successive modifications of the leaf which produced all the other essential parts of the higher plants—the simple cotyledons or seed leaves became modified into the variously formed leaves of the fully grown plants; these again were successively modified into the calyx, corolla, stamens and ovary of the flower. He supposed this to be due to the increased refinement of the sap under the influence of light and air, and to indicate the steps by which the various parts of the flower had been developed. It was, therefore, a theory of evolution; but it was very unsatisfactory, inasmuch as it in no way accounted for the wonderful variety of the floral organs or indicated any purpose served by the most prominent and conspicuous part of the flower, the highly colored and often strangely formed corolla. It was also erroneous in supposing that the corolla was a modified calyx, whereas it is now known to be a modification of the stamens.

Next came the great work of Lamarck in the first decade of the Nineteenth Century, in which he proposed a general system of evolution of the whole animal world. Hence he may be termed the first systematic evolutionist. His system has been rather fully described by Lyell, who, in his "Principles of Geology," devotes a whole chapter to a summary of his doctrines; while Mr. Butler gives copious quotations in three chapters of his "Evolution, Old and New," and any one who is not acquainted with the original work of Lamarck should read these two authors in order to understand how wide was his knowledge, how ingenious his explanations and in how many important points he anticipated the views both of Lyell and Darwin. But he was half a century in advance of his age, and his only alleged causes of modification—changed conditions, use and disuse, habit and effort—were wholly insufficient to account for the vast range of the phenomena presented by the innumerable minute adaptations of living organisms to their conditions of life. He even imputed all the modifications of domestic animals to the changed conditions of food and habits to which they have been subjected by man, making no reference to the use of selection by breeders, in this respect falling short of his great predecessor, Buffon.

The general laws which Lamarck deduces from his elaborate study of nature are these:

"Firstly—that in every animal which has not passed its limit of development, the more frequent and sustained employment of any organ develops and aggrandizes it, giving it power proportionate to the duration of its employment, while the same organ in default of constant use becomes insensibly weakened and deteriorated, decreasing imperceptibly in power until it finally disappears.

"Secondly—That these gains or losses of organic development, due to use or disuse, are transmitted to offspring, provided they have been common to both sexes, or to the animals from which the offspring have descended."

The whole force of this argument depends upon the second clause—the inheritance of those individual modifications due to use and disuse. But no direct evidence of this has ever been found, while there is a good deal of evidence showing that it does not occur. Again, there are many structures which cannot have been produced by use, such, for example, as the feathers of the peacock's train, the poison in the serpent's fangs, the hard shells of nuts, the prickly covering of many fruits, the varied armor of the turtle, porcupine, crocodile and many others. For these reasons Lamarck's views gained few converts; and although some of his arguments have been upheld in recent years, the fatal objections to his general principle as a means of explaining the evolution of organic forms, has never been overcome.

Between the periods of Lamarck and Darwin many advances were made which clearly pointed to a general law of evolution in nature. Such were Sir William Grove's lectures on the "Correlation of the Physical Forces," in 1842; Helmholz on the "Conservation of Energy," in 1847, and Herbert Spencer's essay on "The Development Hypothesis," in 1852. The latter work was a complete and almost unanswerable argument for a natural process of continuous evolution of the whole universe, including organic nature, man and social phenomena. It is further extended in the later editions of the author's "First Principles," which, as a coherent exposition of philosophy, coordinating and explaining all human knowledge of the universe into one great system of evolution, everywhere conforming to the same general principles, must be held to be one of the greatest intellectual achievements of the Nineteenth Century. It left, however, the exact method of evolution of organisms untouched, and thus failed to account for those complex adaptations and appearances of design in the various species of animals and plants which have always been the stronghold of those who advocated special creation. This difficulty was met by Darwin's theory of "The Origin of Species by Means of Natural Selection," published in 1859, and the series of works that succeeded it; and to the brief sketch of this theory the remainder of our space must be devoted.

The Theory of "Natural Selection."

Although, as we have seen, a succession of great writers and thinkers had for more than half a century shown the necessity for some process of evolution as the only rational or intelligible mode of origin of existing species of animals and plants, as well as of the whole physical universe, yet these views were by no means generally accepted by the educated classes, while few bodies of students were less influenced by them than zoologists and botanists, generally known as naturalists.

Now, Darwin wrote especially for these classes, and no one knew better than he did their great prejudice on this matter. Not only had such men as Sir Charles Lyell and Sir John Herschell expressed themselves strongly against all theories of the transmutation of species, but the universal contempt and indignation of naturalists as well as theologians against "The Vestiges of Creation," published anonymously a few years earlier and giving a most temperate and even religious exposition of the general arguments for the universality of evolution, showed what any one might expect who advocated and attempted to demonstrate a similar theory. This accounts for Darwin writing to Sir Joseph Hooker in 1844, of his being "almost convinced that species are not (it is like confessing a murder) immutable," and again in 1845 to the Reverend L. Blomefield, that he now saw the way in which new varieties become exquisitely adapted to the external conditions of life and to other surrounding beings, and he adds, "I am a bold man to lay myself open to being thought a complete fool, and a most deliberate one." It is only by a consideration of the frame of mind of even advanced thinkers at the time Darwin was preparing his work, and remembering how small was the effect which had been produced by Buffon, Goethe, Lamarck, the author of "Vestiges of Creation," and the earlier writings of Herbert Spencer, that we can adequately realize the marvelous work that he accomplished. Let us now briefly consider the essential nature of this new theory, which in a few brief years became the established belief of the great majority of the students of nature, and which also gave a new interest in nature to the whole thinking world.

The theory of natural selection is founded upon a few groups of thoroughly ascertained and universally admitted facts, with the direct and necessary result of those facts.

Restrictions of Increase.

The first group of facts consists of the great powers of increase of all organisms and the circumstance that, notwithstanding this great yearly increase, the actual population of each species remains stationary, there being no permanent increase. Now these two facts were recognized by Buffon, but though, of course, known to all subsequent writers, were fully appreciated or thought out to their logical results by none of them. Lamarck, so far as I can ascertain, took no notice of them whatever. Darwin has given illustrations of these facts in chapter iv of the "Origin of Species," and I have added others in the second chapter of my "Darwinism." That the population of each species remains stationary, with, of course, considerable fluctuations, is both a matter of observation and of reasoning. The powers of increase of all creatures are so great that if there are in any country room and food for a larger number of any species they will be produced in a year or two. It is impossible, therefore, to believe that, in a state of nature where all kinds of animals and plants have lived together as they best could for thousands of years, there can be any important difference in their numbers from year to year or from century to century.

Now it is as a consequence of these two indisputable facts that the struggle for existence necessarily results. For if every year each pair of animals or each plant produces only ten young animals or plants (and this is very far below the average), and if the adult life of these is taken at ten years (again below the average of the higher plants and animals), then, unless some of the parents die the whole of the offspring must die off every year; or, in other words, only as many young can survive as are necessary to replace the old ones that die. Hence the deaths must always (on the average and in the long run) equal the births. This terrible yearly destruction is an absolutely certain fact, as well as an inevitable result of the two preceding facts, and it is said to be due to the struggle for existence.

This struggle is manifold in its nature. Individuals of the same species struggle together for food, for light, for moisture; they struggle also against other species having the same wants; they struggle against every kind of enemy, from parasitic worms and insects up to carnivorous animals; and there is a continual struggle with the forces of nature—frosts, rains, droughts, floods and tempests.

Spencer's "Survival of the Fittest."

These varied causes of destruction may be seen constantly at work by any one who looks for them. They act from the moment of birth, being more especially destructive to the young; and as only one in ten or fifty or a thousand (according to the rate of increase of the particular species) can possibly come to the full breeding age, we feel compelled to ask ourselves: What determines the nine or the forty-nine or the nine hundred and ninety-nine, as the case may be, which die and the one which survives? Darwin calls this process of extermination one of "natural selection"—that is, by this process nature weeds out the weak, the unhealthy, the unadapted, the imperfect in any way. Of course, what may be called chance or accident produces many deaths of individuals otherwise well fitted to live, but if we think of the process going on day by day and year by year till only one in a hundred of those born in a given area are left alive, it is impossible to suppose that the one which has passed through all the dangers and risks which have been fatal to, say his ninety-nine relations was not, in all the faculties and qualities essential to the continuance of the race, decidedly better organized than the bulk of those which succumbed. Herbert Spencer calls the process the "survival of the fittest," and though the term may not be strictly accurate in the case of any one species in any one year, yet when we consider that the struggle is going on every year, during the whole duration of each species, we cannot doubt that, on the whole, and in the long run, those which survive are among the fittest. The struggle is so severe, so incessant, that the smallest defect in any sense organ, any physical weakness, any imperfection in constitution, will almost certainly, at one time or another, be fatal.

This continual weeding out of the less fit, in every generation, and with exceptional severity in recurring adverse seasons, will produce two distinct effects, which require to be clearly distinguished. The first is the preservation of each species in the highest state of adaptation to the conditions of its existence; and, therefore, so long as those conditions remain unchanged, the effect of natural selection is to keep each well-adapted species also unchanged. The second effect is produced whenever the conditions vary, when, taking advantage of the variations continually occurring in all well-adapted and therefore populous species, the same process will slowly but surely bring about complete adaptation to the new conditions.

Of late years, and chiefly since Darwin's works were written, the variability of animals and plants in a state of nature has been carefully studied, by actual comparison and measurement of scores, hundreds and even thousands of individuals of many common, that is, abundant and widely distributed, species; and it is found that in almost every case they vary greatly, and, what is still more important, that every organ and every appendage varies independently and to a large amount. Some of the best known of these facts of variation are adduced in my "Darwinism," and are illustrated by numerous diagrams, and much more extensive series have since been examined, always with the same general result. By large variability is meant a variation of from 10 to 25 per cent on each side of the mean size, this amount of variation occurring in at least 5 or 10 per cent of the whole number of individuals, and in every organ or part as yet examined, external or internal.

Now, as the weeding-out process is so severe, only from one in ten to one in a hundred of those born surviving to produce young, the above proportion of variations affords ample scope for the selection of any variation needed in order to modify the species so as to bring it into harmony with new or changing conditions. And this will be the more easy and certain if we consider how slowly land surfaces and climates undergo permanent changes; and these are certainly the kind of changes that initiate and compel alterations, first, perhaps, in the distribution and afterwards in the structure and habits of species. It follows, therefore, as an absolutely necessary conclusion from the facts, if natural selection can and does keep each continually varying species in close adaptation to an unchanging environment, that it preserves the fixity of its mean or average condition, and almost every objector admits this. Then, given a slowly changing environment, the same power must inevitably bring about whatever corresponding change is needed for the well-being and permanent survival of the various species which are subjected to these changed conditions.

Nineteenth Century Progress.

Space will not permit a further consideration of the objections and difficulties alleged by critics of the theory. All of these have, I believe, been fully answered, either by Darwin or myself, many of the most recent having been discussed in review articles which will shortly be published in a collected form under the title "Studies, Scientific and Social." Suffice it to say here that this theory of natural selection—meaning the elimination of the least fit and, therefore, the ultimate "survival of the fittest"—has furnished a rational and precise explanation of the means of adaptation of all existing organisms to their conditions, and, therefore, of their transformation from the series of distinct but allied species which occupied the earth at some preceding epoch. In this sense it has actually demonstrated the "origin of species," and, by carrying back this process step by step into earlier and earlier geological times, we are able mentally to follow out the evolution of all forms of life from one or a few primordial forms. Natural selection has thus supplied that motive power of change and adaptation that was wanting in all earlier attempts at explanation, and this has led to its very general acceptance both by naturalists and by the great majority of thinkers and men of science.

The brief sketch now given of the progress of human thought on the questions of the fact and the mode of the evolution of the material universe indicates how great has been the progress during the Nineteenth as compared with all preceding centuries.

Although the philosophical writers of classical times obtained a few glimpses of the action of law in nature regulating its successive changes, nothing satisfactory could be effected till the actual facts had been better ascertained by the whole body of workers, who, during the last five centuries, have penetrated ever more and more deeply into nature's mysteries and laws. By their labors we became possessed of such a body of carefully observed facts that toward the end of the last century such thinkers as Laplace and Hutton were enabled to give us the first rudiments of theories of evolution as applied to the solar system and the earth's crust, both of which have been greatly developed and rendered more secure during the century now passing away.

In like manner Buffon and Goethe may be said to have started the idea of organic evolution, more systematically treated a little later by Lamarck, but still without any discovery of laws adequate to produce the results we see everywhere in nature. The subject then languished, till after twenty years of observation and research Charles Darwin produced a work which at once satisfied many thinkers that the long-desired clew had been discovered. Its acceptance by almost the whole scientific world soon followed; it threw new light on almost every branch of research, and it will probably take its place, in the opinion of future generations, as the crowning achievement of the Nineteenth Century.